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Simplifying the Cattellian Psychometric Model

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This chapter concerns the scientific analysis of individual differences in human psychological functioning including personality structure, undertaken by the author over a 30-year period (Boyle, 2006b). A key aspect of this programmatic work has been the taxonomic delineation of psychological constructs relating to cognitive abilities, personality traits (both normal and abnormal), dynamic (motivation) traits, and transitory (emotional/mood) states within the framework of the *Cattellian Psychometric Model* (e.g., see Cattell, 1973, 1979, 1980a,b, 1982a, 1983, 1984, 1988a,b,c, 1990a,b,c; 1995; Cattell & Child, 1975; Cattell & Horn, 1982; Cattell & Kline, 1977; Cattell & Nesselroade, 1984; Cattell et al., 2002). This extensive body of taxonomic psychometric research has been empirical and measurement oriented, using a combination of multivariate experimental and quasi-experimental designs (e.g., Boyle, 1988c; Boyle et al., 1995; Cattell, 1988b,c,e) although some critical reviews and integrative position papers have also been generated (e.g., Boyle, 1985b; Boyle & Cattell, 1987; Boyle & Smári, 2002; Boyle et al., 1999).

Raymond B. Cattell, PhD., DSc (London) was a prodigious, psychometrically-oriented behavioural scientist, listed among the top 10 most highly cited psychologists of the 20th

century (Haggbloom et al., 2002, p. 142). Cattell led a team of internationally visible researchers in undertaking a programmatic series of innovative psychometric research studies into the structure and assessment of human personality and individual differences (e.g., see Cattell, 1980a,b). The *Cattellian School* contributed significantly to the contemporary understanding of human personality constructs, and made numerous psychometric advances, including several technical refinements to exploratory factor-analytic methodology as well as being responsible for the construction of a wide range of factor-analytically derived measurement instruments. Cattell was the recipient of several prestigious awards and prizes, including for example, the *Wenner Gren Prize of the New York Academy of Sciences*, *Distinguished Honorary membership of the British Psychological Society*, the *Darwin Fellowship*, and inaugural president of the *Society of Multivariate Experimental Psychology* (SMEP), which he founded (see Cattell, 1990b). Cattell also was involved in founding the *Institute for Personality and Ability Testing* (IPAT) which is recognized internationally as a major publisher of a wide range of factor-analytically based psychological tests and measurement instruments.

Nevertheless, the report by Haggbloom et al. (2002) confirms that even though both Cattell and Eysenck were listed as among the 10 most highly cited psychologists in the published journal literature (attesting to their vast empirical outputs), the number of citations of their work in general psychology textbooks and in a survey of *American Psychological Society* (now *Association for Psychological Science*) members was disproportionately lower. In Cattell's case, part of the difficulty may reside in the complex mathematical models underpinning the *Cattellian Psychometric Model*, thereby making his writings difficult to comprehend. Moreover, the *Cattellian Psychometric Model* was unnecessarily complicated, including no fewer than 92 primary factors--far too many for practical utility.

Simplifying the overly large taxonomy of Cattellian psychological constructs was demonstrably needed. Accordingly, a sustained, programmatic sequence of exploratory and confirmatory factor-analytic studies was conducted over several years with the goal of elucidating a reduced number of broad factors that would have greater utility for psychological measurement, test construction and professional practice. Other multivariate statistical procedures such as canonical correlation analysis, multiple regression analysis, discriminant function analysis, multidimensional scaling, multivariate analysis of variance, and structural equation modelling were employed, as required (cf. Boyle, 1983b, 1991a; Nesselroade & Cattell, 1988). As a result of this programmatic research, the 92 primary *Cattellian Psychometric Model* factors were reduced down to just 29 broad factors (a 68% reduction)—i.e., 30 broad factors with addition of the separate factor-analytically elucidated curiosity construct (see Boyle, 1983b, 1989a). The resultant *Boyle Psychometric Model*, is not only more concise, but also retains the specificity needed for detailed measurement across several psychological domains including both the normal and abnormal personality spheres (cf. Boyle et al., 2001; Boyle & Smári, 2002).

Thus, a major reduction in number of taxonomic psychological constructs has been achieved through the systematic factor analysis of the primary factor intercorrelations measured in the Cattellian psychometric instruments (see descriptions of instruments in Cattell, 1973, 1988d; Cattell & Schuerger, 1978; Cattell & Johnson, 1986; Curran & Cattell, 1976; Krug, 1980; Schuerger, 1986; Smith, 1988; Sweney et al., 1986). In regard to exploratory factor analytic methodology (see Cattell, 1978; Gorsuch, 1983), an empirical study (Boyle & Stanley, 1986) demonstrated that the simple structure of factor-pattern solutions (cf. Child, 1990) can be maximised by applying a topological rotation in addition to analytical rotation alone (e.g., via the *Statistical Package for the Social Sciences*, SPSS).

Nevertheless, the actual increase in simple structure (measured via the ± 0.10 hyperplane count—see Cattell, 1978) was only about 6%, making it hard to justify all the extra effort required. On the other hand, a critical review of factor-analytic methodology (Boyle, 1993b) appears to have preceded new enhancements being incorporated into the SPSS exploratory factor-analytic programs (e.g., inclusion of the psychometric Scree test—see Cattell, 1988d), increasing the efficiency and practical utility of the current SPSS factor-analytic programs.

In these studies (see Boyle, 2006b), the specific factor-analytic methodology used, mostly employed either an iterative maximum-likelihood or a principal-factoring procedure, together with factor extraction number estimated via careful application of the psychometric Scree test (Cattell, 1978, 1988d). In several empirical investigations (e.g., Cattell & Vogelmann, 1977; Hakstian et al., 1982), the psychometric Scree test had been shown to be considerably more accurate than Kaiser's eigenvalues greater than 1.0 rule (which underestimated the number of factors when there were fewer than about 20 variables, and seriously overestimated the number of factors when there were more than about 40 variables in the analysis). In addition, oblique rotation (either direct Oblimin or Promax) was employed throughout, in the search for maximum simple-structure factor solutions, as indexed via the ± 0.10 hyperplane count (cf. Boyle, 1993b; Cattell, 1978, 1988d; Child, 1990;; McArdle, 1984; McArdle & Cattell, 1994). In future work, it is planned to construct a comprehensive set of modern *neo-Cattellian* psychometric instruments based on the reduced set of broad factors that now has been elucidated. Specifically, the focus will be on the construction of (T-data) objective test measures, thereby avoiding the serious drawback of item-transparent, self-report (subjective) questionnaires, currently so prevalent within the personality assessment field (cf. Boyle, 1985b; Cattell, 1979, p. 123; Schuerger,

1986; Smith, 1988). Accordingly, this chapter not only summarizes an extensive body of past empirical research efforts, but also provides the point of departure for significant future works, based on improved psychometric test construction principles.

A concise taxonomy of psychological constructs (akin to the periodic table in chemistry) is yet to be formulated. Within the framework of the general psychometric model (Kline, 1979, 1980), the initial task is the empirical (factor-analytic) delineation of psychological constructs including cognitive/intellectual abilities, relatively stable personality traits (both normal and abnormal), less stable dynamic (motivational) traits, and transitory, situationally-sensitive mood states. In line with the dictum that measurement is the *sine qua non* of any scientific enterprise, so too, psychological science depends on valid and reliable psychometric instruments that measure inferred psychological (including personality) constructs. Aside from the empirical elucidation and quantitative measurement of psychological constructs, *per se*, psychological science also involves differential empirical studies, and hypothesis testing experimentation (e.g., via functional psychological testing (Cattell, 1986d,e; Cattell & Johnson, 1986; see Boyle, 1989g for a review). In line with Cronbach's (1957) historic call for combining the "two disciplines" of scientific psychology, the published research collated in this chapter has attempted to meld both correlational and experimental approaches within the context of the *Cattellian* framework (cf. Eysenck, 1997), adopting wherever possible, a distinctly multivariate-experimental perspective (Boyle, 1988c, 1991b).

Use of exploratory factor-analytic procedures in the construction of personality instruments has produced somewhat conflicting outcomes. Thus, Eysenck reported three higher-stratum personality dimensions, as measured, for example, in the *Eysenck Personality Questionnaire*

Revised or EPQ-R that were labelled *Extraversion*, *Neuroticism*, and *Psychoticism* (e.g., see Eysenck & Eysenck, 1985), whereas Cattell reported 16 normal personality trait factors (Birkett-Cattell, 1989; Krug, 1981; see Boyle, 1990, for a review of the *Sixteen Personality Factor Questionnaire* (16PF) and *Clinical Analysis Questionnaire* (CAQ) personality trait instruments). Despite being rather unwieldy, the *Cattellian Psychometric Model* has enabled comprehensive measurement of cognitive abilities alongside normal and abnormal personality traits, dynamic (motivational) traits, and situationally-sensitive mood states (cf. Cattell, 1982b, 1988a; Eysenck, 1984). Thus, a key research focus has been the discovery, through use of exploratory factor-analytic methods, of a reduced set of higher-stratum factors within the *Cattellian* framework (Boyle, 2006b). In these studies, many non-Cattellian psychometric instruments have also been utilized both specifically and generically, not only for the purpose of validating or verifying their factor structure, but more importantly, to enable comparisons with instruments constructed within the framework of the *Cattellian Psychometric Model*, and in relation to the more concise, simplified *Boyle Psychometric Model*, subsequently elucidated.

Source traits delineated factor-analytically have been incorporated by the *Institute for Personality and Ability Testing* (IPAT) into several multidimensional measurement instruments including:

- *Sixteen Personality Factor Questionnaire* (16PF)
- *Clinical Analysis Questionnaire* (CAQ)
- *Motivation Analysis Test* (MAT)
- *School Motivation Analysis Test* (SMAT)
- *Children's Motivation Analysis Test* (CMAT)
- *Eight State Questionnaire* (8SQ)
- *Objective-Analytic (O-A) Battery*

- *Culture Fair Intelligence Tests* (CFIT)
- *Comprehensive Ability Battery* (CAB).

Despite Cattell's enormous productivity, the complexity of his "all-inclusive" psychometric approach has tended to be rather problematic, serving as an ongoing source of frustration for many psychological researchers and practitioners alike. Indeed, as stated above, Cattell had elucidated no fewer than 92 primary factors, including 20 cognitive ability factors, 16 normal personality trait dimensions (including 16PF Factor B, Intelligence), 12 abnormal personality traits, 20 integrated/unintegrated dynamic traits, 12 normal mood states; and 12 abnormal mood states (derived from dR-factor analyses of *Clinical Analysis Questionnaire* subscale intercorrelations), which was too unwieldy for practical utility. It was evident that a reduction in number of taxonomic constructs was urgently needed (Kline, 1979, 1980), and the *Cattellian Psychometric Model* with its emphasis on numerous primary factors, provided a logical starting point for elucidating a reduced set of pertinent higher-stratum constructs. In contrast, the *Eysenckian Psychometric Model* (EPM) was too minimalist, accounting for only a small fraction of the known personality trait variance (cf. Boyle et al., 1995; Cattell, 1986g, 1995). Thus, the Eysenckian factors provided an inadequate account of the dimensionality of abnormal personality structure (i.e., the unitary *Psychoticism* scale is problematic in light of the several varieties and subtypes of psychopathology documented in the DSM-IV-TR or ICD-10 psychodiagnostic classification manuals, respectively). Additional goals (Boyle, 2006b) also included the clarification and refinement of methodological issues relating to exploratory factor analysis, as well as undertaking empirical studies into personality within various applied settings.

Several of the studies presented in this chapter were published either in *Multivariate Experimental Clinical Research* or in *Personality and Individual Differences*, in order to disseminate the research findings to the comparatively small, but select target audience interested in multivariate psychometric research related to personality and individual differences within the Cattellian framework. In contrast to more subjective test construction approaches, the empirical use of factor analysis was used to map out the important underlying psychological constructs, and the derived factors guided subsequent construction of measurement instruments (e.g., Boyle, 1992, 1999). Importantly, since each of the Cattellian instruments including the *Sixteen Personality Factor Questionnaire* or 16PF (Cattell et al., 1970; Krug, 1981), the *Motivation Analysis Test* or MAT (Cattell, 1985; Cattell & Child, 1975; Sweney et al., 1986), and the *Eight State Questionnaire* or 8SQ (Curran & Cattell, 1976) measured essentially discrete variance (see Boyle et al., 1985), and in light of relevant psychometric principles (Boyle, 1985b), the search for higher-stratum factors within each intrapersonal psychological domain appeared especially promising. Accordingly, the sustained program of multivariate research studies presented here comprised many factor analyses of empirical data derived mostly from large samples that cumulatively involved psychometric assessment of many thousands of individuals.

Boyle (1989f) and Fisher and Boyle (1997) reported the higher-stratum factor structure of normal personality traits measured in the *Sixteen Personality Factor Questionnaire* (cf. Cattell, 1994, 1995; Cattell & Krug, 1986; Krug & Johns, 1986), thereby providing support for a simplified and more practical structure of five broad personality dimensions (a 69% reduction). In a factor analysis of the subscale intercorrelations of the 16PF/MAT/8SQ instruments (the first ever such combined study), Boyle (1988c) also reported three additional normal personality dimensions, thereby enabling measurement of a substantially

greater proportion of the personality trait variance than that provided by the Eysenkian factors. Previously published data for the 16PF, the *Comrey Personality Scales*; and the *Eysenck Personality Inventory* (an early version of the *Eysenck Personality Questionnaire* or EPQ) was subjected to close scrutiny (Boyle (1989f) using methodologically sound factor-analytic procedures (see Boyle, 1985b, 1988c, 1993b; Boyle & Stanley, 1986; and Boyle et al., 1995, for specification of the factor-analytic methodology employed). Results of this well-cited reanalysis confirmed the work of Krug and Johns (1986) that there are at least five broad normal personality factors labelled: *Extraversion*, *Anxiety-Neuroticism*, *Tough Poise*, *Independence*, and *Control*. These five second-stratum factors have made a substantial impact, having been incorporated, for example, into the revised *Sixteen Personality Factor Questionnaire* (5th edition or 16PF5; see H.E.P. Cattell, 2001, 2004; R.B. Cattell & H.E.P. Cattell, 1995; Cattell & Schuerger, 2003). These higher-stratum 16PF5 factors were shown to compare more than favourably with other models of personality structure such as the currently popular *Five Factor Model* (FFM)—(see Boyle, 2006a; Fisher & Boyle, 1997), and were found to correspond with primary T-data factors measured in the *Objective-Analytic Battery* (OAB)--(Cattell & Birkett, 1980).

Boyle et al. (1995) in their chapter in the *International Handbook of Personality and Intelligence* provided a detailed technical critique of the exploratory factor-analytic research leading to development of both the *Sixteen Personality Factor Questionnaire* and the currently popular *Five Factor Model* (cf. Boyle, 2006a; H.E.P. Cattell, 1993). Importantly, simple structure for the *Sixteen Personality Factor Questionnaire* second-stratum factor solution (measured via the ± 0.10 hyperplane count—see Cattell, 1978) was significantly greater than that observed for the *Five Factor Model* (Boyle et al., 1995; Boyle & Smári, 1997, 1998, 2002; Boyle & Saklofske, 2004; Krug & Johns, 1986),

suggesting that the *Sixteen Personality Factor Questionnaire* second-stratum factors provide a more satisfactory structuring of the normal personality trait domain than does the popular *Five Factor Model*. However, since the second-stratum Factor QIII (*Tough Poise*), calculated via the algorithm provided in the *16PF Handbook* produced spurious results, Boyle and Robertson (1989) recommended that previous studies involving the computation of second-stratum *Sixteen Personality Factor Questionnaire* factors should be reanalysed in light of the new corrected algorithm. Since historically, the *Sixteen Personality Factor Questionnaire* has been the most highly cited psychometric measure of normal personality, the potential impact of correcting this computational error was considerable.

Parenthetically, we had demonstrated (Cattell et al., 2002) that personality traits are susceptible to modification as a function of life experience, indicative of substantial “structural learning” (see Cattell, 1983; Cattell et al., 2002; Roberts et al., 2006a,b). This finding casts doubt on the adequacy of “static” models of personality structure such as the *Five Factor Model*, thereby providing an advance in our understanding of the structuring of human personality. This new knowledge that personality traits are not fixed, immutable dispositions, but rather are only relatively stable dispositions that are subject to structural change (e.g., as a result of learning and enculturation) undoubtedly will impact greatly on the future construction of personality measurement instruments.

Boyle (1987b) also reported a number of second-stratum factors within the abnormal personality trait domain. The 12 abnormal (psychopathological) trait dimensions measured in the *Clinical Analysis Questionnaire* or CAQ (Krug, 1980) were reduced down to just six second-stratum factors (a 50% reduction) that were labelled: *Depressive Schizophrenia*, *Psychopathic Dominance*, *Psychotic Inadequacy*, *Paranoid Depression*, *Helpless*

Depression, and *Anxious Depression*, thereby providing a much greater economy of measurement. Furthermore, the seven primary *Clinical Analysis Questionnaire* depression factors were reduced down to just four broad depression factors, having greater practical, conceptual and measurement utility for researchers and professional psychologists alike (cf. Boyle & Comer, 1990). It is to be hoped that the impact of these findings will likely be realised with future construction of more efficient measures of abnormal personality, based on broad second-stratum, rather than focusing on a plethora of narrow primary trait factors.

Turning to the dynamic (motivation) trait domain (e.g., see Barton et al., 1986; Cattell, 1981, 1985; 1992; Cattell & Child, 1975; Cattell & Kline, 1977; Kline, 1979) several publications (e.g., Boyle, 1985a, 1988c, 1989b; Boyle & Start, 1988, 1989a; and Boyle et al., 1989a) examined the higher-stratum factor structure of objective motivation tests (T-data measures avoid the problematic item transparency and associated response distortion that plagues Q-data self-report personality questionnaires). While objective tests of cognitive abilities have been used for decades, the use of objective motivation tests has been less prominent. A notable exception has been the Cattellian work with its incorporation of objective T-data tests into the *Motivation Analysis Test* (MAT) and its downward extensions, the *School Motivation Analysis Test* (SMAT) and *Children's Motivation Analysis Test* (CMAT), respectively (Boyle et al., 1988; Cattell, 1985, 1992; Cattell & Child, 1975; Cattell & Warburton, 1967).

Some early work (e.g., Boyle & Cattell, 1984) had examined *Motivation Analysis Test* construct and predictive validity. It was found that presentation of a stressful stimulus induced significant elevations in several dynamic traits (especially *Fear*), lending confidence that factor-analytic refinements would be efficacious (parenthetically, the

empirical findings obtained by Boyle and Cattell also suggested that fear appeals, in the absence of positive instructions, are likely to be ineffective in promoting safer driving behaviours). An earlier factor analysis of the subscale intercorrelations of the MAT/8SQ instruments was subsequently revised (Boyle, 1985a) using more methodologically sound factor-analytic procedures, resulting in reduction of the 20 integrated/conscious (I) and unintegrated/unconscious (U) primary *Motivation Analysis Test* dimensions down to just seven second-stratum factors (a 65% reduction). The broad dynamic trait factors delineated were labelled: *Home Orientation*, *Pugnacity*, *Narcism* (narcissism), *Career Orientation*, *Fear*, *Self-sentiment*, and *Superego* (specific factor-analytic procedures were provided in Boyle, 1993b). Accordingly, an updated, simplified *Motivation Analysis Test*, constructed to measure the above higher-stratum factors, would make the instrument more useful as a measure of dynamic traits. The impact of such a revised addition to the psychometric armamentarium would likely be considerable, since objective T-data tests of motivation are rare.

Boyle (1989b) also investigated higher-stratum factors in the *School Motivation Analysis Test* (version used with adolescents). The 20 (U and I) primary factors were reduced down to just five second-stratum factors (a 75% reduction). In line with the recent verification that personality structure can be modified somewhat as a result of experience (Cattell et al., 2002), so too, reduction in second-stratum factors (five SMAT factors versus seven MAT factors) pointed to the developmental nature of motivational structure. In Boyle et al. (1989a), evidence for a possible sixth second-stratum *School Motivation Analysis Test* factor was obtained. However, variation in factor pattern solutions suggested that, as with the objective *Motivation Analysis Test*, further psychometric refinement of the *School Motivation Analysis Test* was also required (cf. Boyle et al., 1989a,b). Hopefully, such a

revised objective T-data instrument would enable the valid measurement of factor-analytically elucidated dynamic traits among adolescents.

In addition, Boyle and Start (1988) reported broad second-stratum *Children's Motivation Analysis Test* factors (version used with primary school children). The four factors that emerged (an 80% reduction) were labelled: *Superego*, *Narcism* (narcissism), *Play*, and *Self-sentiment*. It was noted that *School Orientation* (second-stratum SMAT factor) was not included among the *Children's Motivation Analysis Test* second-stratum factors, suggesting perhaps that primary school children have not yet developed a strong motivational focus on school activities (cf. Boyle & Houndoulesi, 1993). This finding is consistent with the observation that motivational structure itself is partly a product of experiential learning, wherein sentiments are culturally acquired. In a comparison of gender differences in motivation (Boyle & Start, 1989a,b), the second-stratum factor loadings for primary school boys and girls differed appreciably, suggesting general differences in interests and motivational structure. Girls obtained significantly higher mean scores on *Fear*, *Pugnacity*, and *Curiosity*, whereas boys obtained significantly higher scores on *Play*. Theoretically, at least, if these observed gender differences in motivation were taken into account and explicitly capitalised upon with the aim of producing enhanced educational outcomes, the impact of this finding could be considerable.

A research note (Boyle (1989c) reported the first available normative data for the (unpublished) *Children's Motivation Analysis Test*. Provision of this normative data was useful, establishing an objective basis for comparing children's *Children's Motivation Analysis Test* scores. In a study that manipulated curiosity and boredom states, Boyle et al. (1993) provided some predictive validity for the instrument. Four of the 20 (U and I)

CMAT factors exhibited significant changes in mean scores following experimental interventions (decreases were observed in *I-Assertiveness* and *I-Fear*; increases were observed in *U-Narcism* and *U-Pugnacity*). These findings (cf. Boyle & Cattell, 1984) provided further evidence of the situational sensitivity of the dynamic trait factors. It was observed also that *Superego* and *Self-sentiment* appeared to emerge factor analytically as “master sentiments” for all three MAT/SMAT/CMAT instruments. Finally, Boyle (1988c)--in the *Handbook of Multivariate Experimental Psychology*--summarized the psychometric findings from several empirical studies carried out conjointly into the MAT/SMAT/CMAT instruments. While some evidence of predictive or discriminative validity was observed in each case, it was also apparent that these instruments need extensive psychometric revision, not only to simplify their factor structure, but also to bring them up-to-date for contemporary use.

Turning to the mood-state domain, both canonical correlation analyses and multiple regression analyses, as well as several exploratory factor analyses were undertaken in an attempt to quantify the measurement overlap (in terms of percentage of common measurement variance) across the 8SQ/DES-IV instruments (Boyle, 1986, 1989d). Results demonstrated that only a small number of the *Differential Emotions Scale* (DES-IV) subscales predicted most of the 8SQ variance, and vice versa, showing that the *Eight State Questionnaire* (8SQ) alone does not provide comprehensive assessment of the mood-state domain. Redundancy analyses of the 8SQ/POMS instruments (cf. Boyle, 1987b) demonstrated that the *Eight State Questionnaire* and *Profile of Mood States* (POMS) instruments measured considerable discrete variance, supporting the search for higher-stratum state factors from factor analyses of all three 8SQ/POMS/DES-IV mood-state instruments.

Accordingly, several factor-analytic studies (Boyle, 1987d, 1988a, 1989e, 1991c) sought higher-stratum mood state factors from the 8SQ/POMS/DES-IV instruments (while Cattell had delineated 12 mood-state factors, only the first eight were incorporated into the 8SQ). The outcome of these studies was a significant reduction from 12 primary factors down to just four broad mood-state factors (a 67% reduction) that were labelled: *State Extraversion*, *State Neuroticism*, *State Hostility*, and *Arousal-Fatigue*, respectively. In addition, a differential (dR) scale factoring of the *Clinical Analysis Questionnaire* (Boyle, 1987a) provided evidence for two abnormal mood-state factors (an 83% reduction) that were labelled *Paranoid State* and *Psychopathic Dominance State*, respectively (cf. Cattell & Kameoka, 1985). Taken together, these findings provided justification for the construction of new simplified scales that focused on broad second-stratum dimensions. In Boyle and Katz (1991), multidimensional scaling (MDS) of 8SQ/DES-IV data also revealed that most DES-IV subscales were aligned in close proximity to each other, suggesting inadequate separation, and therefore suggesting the need for psychometric refinement of the *Differential Emotions Scale*. In contrast, separate factor analyses of the POMS/8SQ (see Boyle, 1988a) confirmed the purported factor structure for each instrument.

In regard to the taxonomic structure of cognitive abilities, a hierarchical model comprising broad higher-stratum factors, several primary factors, and numerous specific abilities also had been postulated within the *Cattellian Psychometric Model* (e.g., Cattell, 1982a, 1987a; Cattell & Cattell, 1977). Boyle (1988b, 1995) reported that both *Fluid* (G_f) and *Crystallised* (G_c) intelligence factors are accompanied by a number of important second-stratum ability factors labelled: *Memory Capacity* (G_m), *Perceptual Speed* (G_{ps}), *Retrieval Capacity* (G_r), *Visualisation Capacity* (G_v), and *Auditory Organisation* (G_a). This

reduced number of ability factors, as compared with say the 20 primary factors measured in the *Cognitive Ability Battery* (CAB), would appear to have greater practical utility (a 75% reduction). While these higher-stratum cognitive ability factors have been incorporated to some extent into existing ability measures there appears to be room for construction of a new, simplified intelligence test that simultaneously measures each of the higher-stratum factors and builds on well-established instruments such as the *Stanford-Binet Intelligence Scale* (SB-IV) and the *Wechsler Intelligence Scales*. Boyle (1990b) and Bernard et al. (1990) reported exploratory, congeneric and confirmatory factor analyses of SB-IV data that supported the four putative Area dimensions (*Verbal Reasoning, Quantitative Reasoning, Abstract-Visual Reasoning, and Short-Term Memory*). Boyle (1993a, 1995) as well as Boyle et al. (1995) and Stankov et al. (1995) examined the covariation between personality and cognitive ability measures. Their findings revealed only slight measurement overlap, suggesting that personality and ability factors measure essentially discrete psychological domains.

Other psychometric studies, either arising from or benefiting research into the Cattellian Psychometric Model, contributed new insights relating to: (1) use of change scores in canonical-redundancy analyses of multidimensional mood-state instruments, thereby avoiding “trait contamination variance” (Boyle, 1987e). This study demonstrated that neither the *Eight State Questionnaire* nor the *Differential Emotions Scale* provided comprehensive coverage of the mood-state domain, highlighting the need to include additional scales in factor analyses of mood-state data. (2) desirable levels of item homogeneity in psychometric scales (Boyle, 1991a). This highly cited study demonstrated that to achieve greater breadth of measurement, item homogeneity (e.g., as measured via the Cronbach alpha coefficient) should be moderate rather than maximal. (3) validity of

meta-analytic procedures (Fernandez & Boyle, 1996). This paper highlighted the importance of framing hypotheses in a rigorous operational manner, making adjustments and taking sample size into account in estimating effect sizes. (4) test validity as a function of method of administration (Grossarth-Maticek et al., 1995). This study demonstrated that the outcomes of psychological investigations may depend greatly on the particular test administration method employed. Taken together, these and other methodological papers have clarified several important psychometric issues, serving as an essential prerequisite for improved psychological test construction. In addition, substantive advances have included calculation of measurement redundancy across different instruments via canonical correlation analyses (e.g., 16PF/MAT); derivation of multiple regression prediction equations for translating scores across different measures (e.g., 8SQ/POMS/DES-IV); as well as elucidation of higher-stratum factors for both normal and abnormal (psychopathological) personality traits (16PF/CAQ), dynamic (motivation) traits (MAT/SMAT/CMAT), and transitory mood states (8SQ), respectively.

This sustained research program has also culminated in a number of integrative technical reviews and position papers (e.g., Boyle & Smári, 2002; Boyle et al., 2001; Fisher & Boyle, 1997) some of which were published in foreign-language peer-reviewed journals (Norwegian, Spanish, French, plus some abstracts in German and Japanese), thereby increasing international visibility and dissemination of the findings. Finally, Boyle and Saklofske (2004) provided a comprehensive and relatively up-to-date integrative overview of research findings within the field of personality and individual differences.

Summary of Major Outcomes of this Research:

- Justification of the search for higher-stratum factors, since 16PF/MAT/8SQ measured substantial discrete variance.
- Reduction of 16PF primary factors down to five broad factors. (*69% reduction*)
- Demonstration of significantly greater simple structure for the 16PF second-stratum factors than for the FFM.
- Reduction of 12 CAQ abnormal personality trait dimensions down to six broad factors. (*50% reduction*)
- Reduction of 20 (U and I) MAT factors down to seven broad factors.
(*65% reduction*)
- Reduction of 20 (U and I) SMAT factors down to five broad factors.
(*75% reduction*)
- Reduction of 20 (U and I) CMAT factors down to just four broad factors.
(*80% reduction*)
- Demonstration that *Superego* and *Self-sentiment* emerged as “master sentiments” for all three MAT/SMAT/CMAT instruments.
- Reduction of 12 (8SQ/POMS/DES-IV) primary mood-state factors down to just four broad factors. (*67% reduction*)
- Elucidation of two abnormal CAQ mood-state dimensions. (*83% reduction*)
- Reporting of five broad ability factors. (*75% reduction*)
- Reduction of 92 *Cattellian Psychometric Model* primary factors (ability, personality, motivation, and mood-state domains) down to 29 broad factors. (*68% reduction*)
- Production of simplified *Boyle Psychometric Model* (30 broad factors with inclusion of the curiosity construct).

Methodological Recommendations

- Evaluate item homogeneity in terms of *both* internal consistency *and* item redundancy and to enhance breadth of measurement by including greater diversity of items in psychometric scales.
- Use *objective personality tests* rather than subjective, item-transparent self-report scales (to avoid motivational/response distortion).
- Measure reliability via immediate and longer-term test-retest (*dependability* vs. *stability*) estimates for state-trait measures.
- Use methodologically sound exploratory factor-analytic (EFA) methods.
- Demonstrated that *method of test administration* significantly influences predictive validity of psychometric tests.

Summary and Conclusions

This sustained body of empirical research (Boyle, 2006b) has pinpointed a number of limitations in the psychometric assessment of personality and individual differences within the framework of the *Cattellian Psychometric Model*. It has identified several important questions needing to be addressed, and has included many experimental and/or empirical studies, providing a set of more practical taxonomic constructs for effective use by the psychological, medical, educational and commercial communities. The extensive body of taxonomic research provides a practical solution to the extreme/conflicting positions adopted by earlier investigators (e.g., Cattell's comprehensive approach versus Eysenck's minimalist approach). Over many years, through the sustained application of factor analysis, a simplified version of the *Cattellian Psychometric Model* has been produced, resulting in a 68% reduction from 92 factors down to 29 broad factors. With inclusion of the State Curiosity dimension (also elucidated factor analytically), the *Boyle Psychometric*

Model, comprises 30 broad factors that, taken together, cover the intrapersonal psychological domains of cognitive abilities, personality traits, dynamic traits, and transitory mood states, respectively (see Table 1).

 Put Table 1 about here

The next sequential step will be to construct a wide range of modern neo-Cattellian multidimensional psychometric instruments, incorporating the reduced number of higher-stratum factors into objective test measures (rather than relying on item-transparent questionnaires with their inherently flawed self-report methodology). The plethora of so-called "personality tests" has literally exploded in recent years. Many of these are relatively simple rating scales (ratings of others or L-data; self ratings or Q-data). Aside from response sets, and superficial reporting, a major problem with subjective L-data and Q-data rating scales of personality/motivation is that they depend upon transparent, face valid items. Item transparency is extremely problematic, inviting response/motivational distortion, such that virtually all current "personality testing" is essentially based on subjective methodology. Correction scales can go only so far, and in some cases (e.g., the *Minnesota Multiphasic Personality Inventory* or MMPI K-scale) application of the proposed modification may produce "corrected" scores that are no more accurate than the "uncorrected" ones.

What is needed are truly *objective interactive tests* of personality traits (with computer implementation, and stimulus items individualised for each respondent). Indeed, Cattell

and Warburton (1967) had produced a compendium comprising more than 2000 objective T-data personality tests, several of which were subsequently incorporated into the *Objective Analytic Battery* (Cattell & Schuerger, 1978). Evidently, the field of personality measurement needs to be transformed out of its present quagmire (based predominantly on subjective self-report methodology) and lifted onto an altogether more technologically advanced level of objective-interactive testing (Schuerger, 1986).

Hopefully, neo-Cattellian instruments constructed to measure the higher-stratum factors delineated in the *Boyle Psychometric Model* should take approximately 70% less time to administer than is currently required for all 92 *Cattellian Psychometric Model* primary factors using the currently available spectrum of Cattellian instruments (Boyle, 2006b). Such a major saving in testing time should have a considerable beneficial impact for various areas of psychological research and professional practice. Thus, the work presented in this chapter is more than just a summary of past research efforts. It also provides a rich source of hypotheses, and lays the very foundations for challenging and rewarding future works and directions in personality test construction.

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Table 1

Reduced Set of 30 Broad Factors -- Boyle Psychometric Model

Normal Personality: (five factors)

Extraversion, Neuroticism, Tough Poise, Independence, Control

Abnormal Personality: (six factors)

Depressive Schizophrenia, Psychopathic Dominance, Psychotic Inadequacy, Paranoid Depression, Helpless Depression, Anxious Depression

Motivation: (adult--seven factors)

Home Orientation, Pugnacity, Narcism (narcissism), Career Orientation, Fear, Self-sentiment, Superego

Normal Mood States: (five factors)

Extraversion State, Anxiety-Neuroticism State, Anger-Hostility State, Curiosity State, Arousal-Fatigue State

Abnormal Mood States: (two factors)

Paranoid State, Psychopathic Dominance State

Cognitive Abilities: (five factors)

Memory Capacity, Perceptual Speed, Retrieval Capacity, Visualisation Capacity, Auditory Organisation